March 29,1999

LW400B MANUAL ADDENDUM

This addendum applies to the LW400B WaveSation:

The LW400B is similar to the LW400 and LW400A except that it does not have the internal asynchronous pseudorandom noise source. An external noise source can be applied to the rear of the WaveStaion as describe in chapters 9 and 10 that follow. Refer to chapters 9 and 10 contained in this addendum instead of those contained in the *LW400/LW400A Series AWG Operators Manual* that is included with your LW400B.

Remote programming of the LW400B

Command changes related to the use and control of of the external noise input on the LW400B are included in the Remote Command Addendum. The commands included it this addendum replace those contained in the *LW400/LW400A Remote Programming Guide.*

There is also a new command used to remotely enter the continuos clock mode.

Adding Noise To Waveforms

The WaveStation allows users to add controlled amounts of noise to waveforms in two ways. Synchronous pseudorandom noise can be added using equations. Noise created in this way is repeatable and is the same every time the waveform is output.

On LW400 and LW400A models, internally generated, asynchronous noise can be added to the waveform (not available on the LW400B). This noise, uncorrelated with the waveform, is generated by an independent pseudorandom noise generator and summed into the output channels.

The LW400, LW400A, and LW400B models all include a rear panel BNC input for application of an external noise source.

Synchronous Noise

Synchronous noise is added to waveform equations using either of two noise arguments, **NOISE** or **GNOISE**. Both **NOISE** and **GNOISE** are "white" noise sources; i.e. their signal energy is uniformly

	NOISE	**GNOISE**
Frequency Distribution	Uniform	Uniform
Amplitude Distribution	Uniform	Gaussian
Amplitude Range	0-1 V	0-1V
Mean	0.5	0.5
Standard Deviation	0.288	0.1667

distributed in the frequency domain. **NOISE** has a uniform amplitude distribution, while **GNOISE** provides a Gaussian amplitude distribution. The statistical characteristics of the noise arguments are summarized in the following table:

The random number generator used in the equation editor creates the same noise sequence each time it is initialized at power up. Subsequent equation calculations, made without cycling power, return different noise sequences. In either case, the noise component added to each sample within the waveform is fixed and cannot be changed without re-calculating. To recreate a waveform with a different set of noise components, simply recalculate the waveform.

Figures 9.1 and 9.2 illustrate the use of **GNOISE** in adding noise to a damped sinewave:

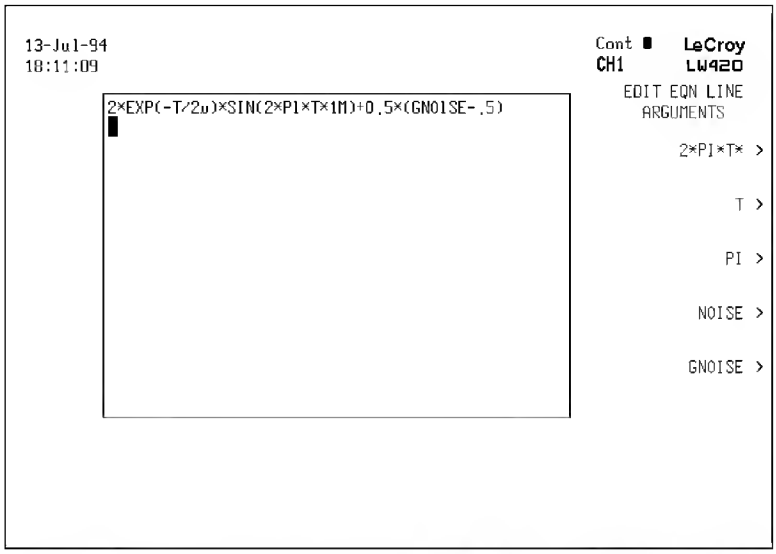


Figure 9.1 Equation of a Damped Sine with additive noise

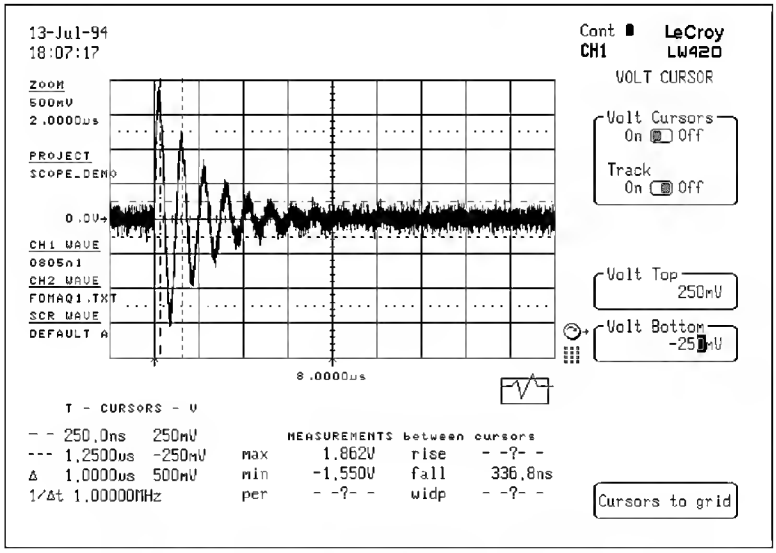


Figure 9.2 Damped Sine with additive noise

Using the noise source on the LW400 and LW400A

The independent pseudorandom noise generator uses a nominal 800 MHz clock source which is asynchronous with the Wavestation's internal timebase. It produces spectrally uniform white noise with a Gaussian amplitude distribution. The pseudo-random pattern length is 2^{22} states. The noise can be added to the output channel(s). The summation point is prior to the gain/attenuation stages so that the signal to noise ratio is fixed regardless of the signal path gain.

Pressing the CHAN1 (or CHAN2 on the LW420 or LW420A) will display the CH1 (CH2) menu which contains the controls for adding noise to the selected channel—see figure 9.3.

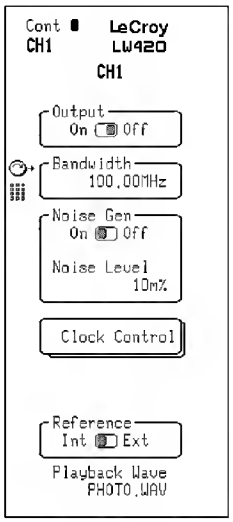


Figure 9.3 Setting the Asynchronous noise level

Using an external noise source on the LW400B

The LW400B series does not include the internal noise source however a noise source can be supplied externally though the noise input BNC located on the rear panel. The noise is summed internally and controlled in a way similar to the models that contain the internal noise source—see figure 9.3.

The recommended noise input level is 1.0 V peak to peak with 0.0 V offset.

Note that since the noise is added independent of the selected waveform creation process it does not appear on the waveform display.

Noise Control

Noise may be added to either or both channels in the dual channel models. The noise level is independently adjustable in each channel. The noise level is specified as a percentage of the noise amplitude (in Volts RMS) to the currently selected waveform's amplitude (in Volts peak-to-peak) to a maximum of 9%. This assumes that the AWG's output bandwidth is set to the maximum, 100 MHz, setting.

Example:

For A Signal Amplitude Of 1 Vpp And A Noise Level of 9%

$V_{NOISE}=1 \times 0.09V_{RMS}$ (Gaussian Noise)

For Gaussian Noise the Peak to Peak Noise is:

$V_{NOISE}(P\text{-}P)+6V_{NOISE\ RMS}$

Note: The noise source is uncalibrated, therefore the noise level should be measured and set to your specific requirements. For Gaussian Noise: V_{RMS}*=1 (sigma) and Peak to Peak=6 x* V_{RMS}

Shaping The Noise on the LW400 and LW400A

The noise generator output can be routed through an external filter to shape the noise spectrum. The filter, which should have an impedance of 50 Ω, may be connected between the noise output and input BNC connectors in slot 1 on the rear panel.

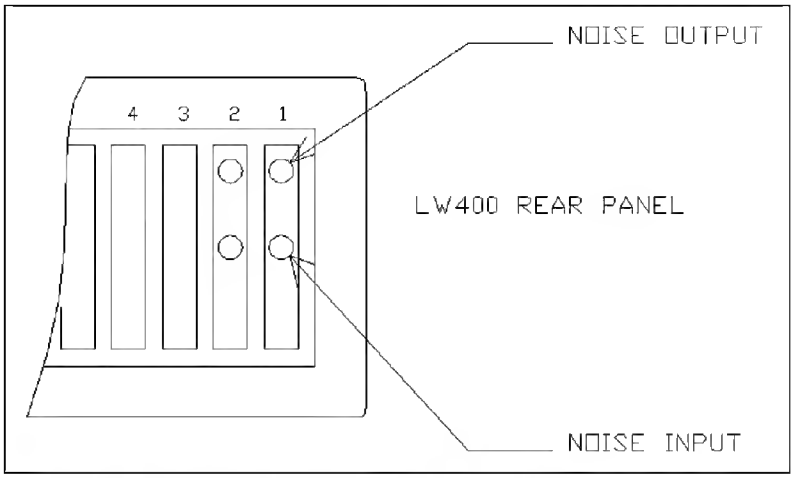


Figure 9.4 rear panel connections for the noise generator

The external noise path is selected from the SYSTEM menu as shown in figure 9.5. This can be accessed by pressing the PROJECT button and then selecting the Preferences and System softkeys.

Note for LW400B Series: *The Noise Path Menu box does not appear on the LW400B series. The noise path is always external on the LW400B.*

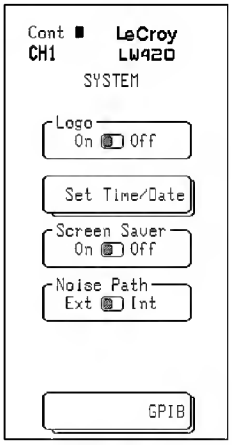


Figure 9.5 Selecting the noise path

The project structure of the WaveStation is intended to provide a logical place to group waveform files and certain system parameters. It is intended to facilitate the use of the instrument in a multi user environment where different users can have their own unique directory of waveforms. Within the user directories, waveform files can be stored along with certain system setup files that define the configuration of the LW400 at start up or initialization.

The project structure can be likened to the file manager in modern computer operating environments such as "windows™" in that it gives the user an easy way to access a hierarchy of directories, called projects in the WaveStation, and to move files into and out of each project directory in WaveStation, as well as between project directories. It also gives the user a way to write protect his or her files should it be necessary.

The multi disk file management capability provides support for importing and exporting large waveforms and projects.

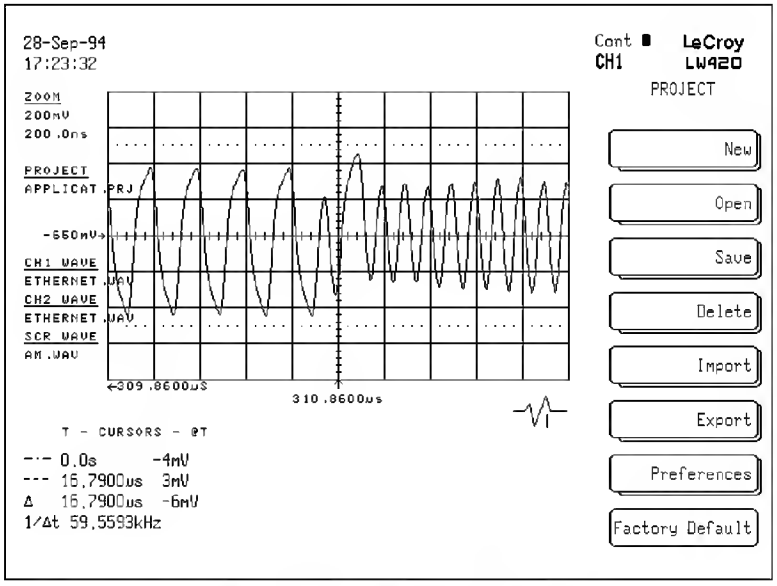


Figure 10.1 The Project Menu

Project Structure

New	Assign a name to a New Project
Open	Choose an existing project from a list and open it
Save	Will save changes to current project or "save as" to change name
Delete	Delete a waveform, sequence, equation or project
Import	Get something from various available sources (see below)
Export	Send something to various available destinations (see below)
Preferences	Sets a myriad of initial conditions (see below)
Factory Default	Set to known state—default settings

Table 10.1 Selections in the Project menu

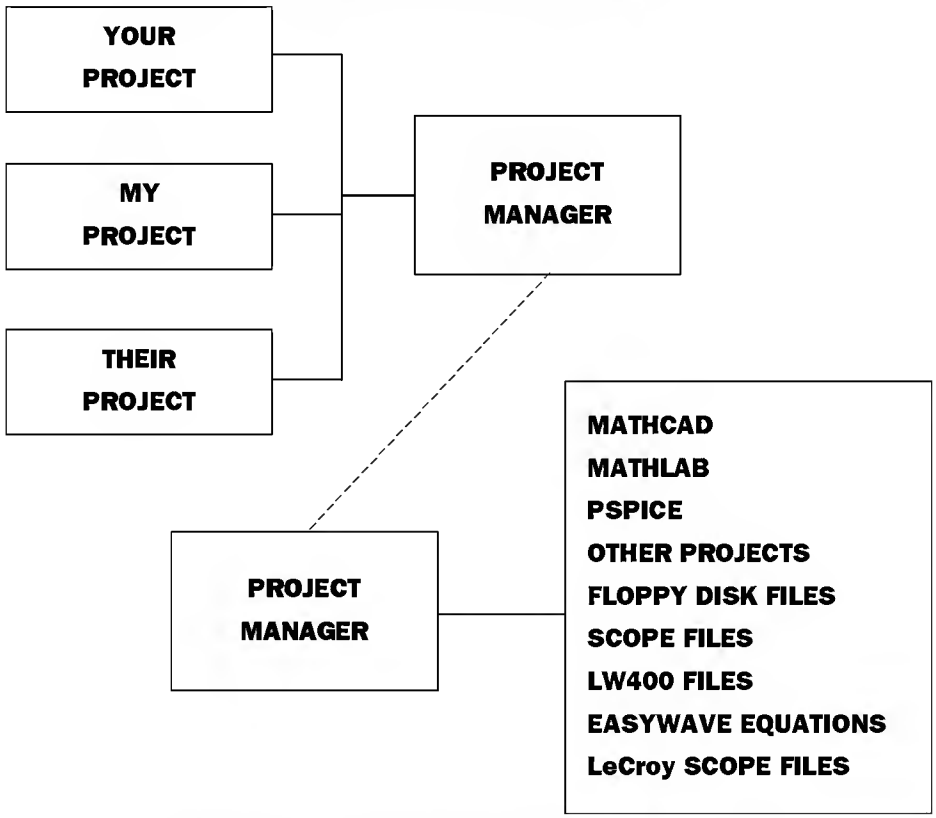


Figure 10.2 The Role of the Project Manager

Project Menu

New — This menu is used to create and name a new project.

Open — This menu is used to select an existing project.

Save — On entry to the menu this field contains the name of the open project. If a name is entered in the Save As menu (see below) then this field contains that name.

Save As — This menu is used to change the name under which the current project will be saved.

Save It — Saves the current project. *Note: if the project is write protected then the user will be told it's a write protected project and abort the save operation. If a new name was entered for the project (**Save As**) then a new project is created from the current project. This includes all waveforms, sequences, equations and project preference settings. The old project is closed (no prompt is given if settings have changed) and the new project is opened.*

Project Delete

Delete

This is the only place to delete projects, waveforms, sequences, equations, or DSO files. Everything comes in and out of the LW400 through the project menu. The current and default projects may not be deleted. Anything in a write protected project may not be deleted. After delete is pressed then a message appears to verify delete.

What

This field contains the different types of objects that can be deleted; Projects, Waveforms, Sequences, Equations and DSO files. This field dictates what type of objects are shown in the next field. The rotary knob is attached to this field.

Projects

This field contains the objects that can be deleted (dependent on the What field). The label for this field changes in accordance with the What field. If the What field contains Sequence the label will be Sequences. The different labels for this field are: Projects, Waveforms, Sequences, and Equations.

Delete

This is the action softkey that begins the delete operation (dependent on the Are You Sure button) of the object in the fields described above. If the object is write protected it will not be deleted and the appropriate message will be given to the user.

Import—Refer to section 12 for additional details

What

The following object types that can be imported into a project: LW4XX Waveform, LW4XX Sequence, LW4XX Equation, LW4XX Project, EasyWave Wave, EasyWave Wad, EasyWave Seq, LeCroyScopeFile, MathCad File, PSpice File, MatLab File, ASCII(Data,Hex,Binary), Spread Sheet File or DSO file.

From

This is the location of the object to be imported. Objects can be imported from other projects, or a floppy disk.

Path/Project

This is the actual path to the objects. The appearance of this field depends on the **From** field. If the **From** field displays Another Project, then this field is a list of valid projects. If the **From** field displays Floppy Disk, then this field is a menu labeled **Path.** The path submenu permits selection of the floppy disk subdirectory.

Source File

This is the object to be imported. The list contains the objects found in the **Project/Path.**

Target File

This is the name assigned to the imported object. It will duplicate the name in the **Source File** field until it is changed with **Import As** (see below) at which point it will be the name entered.

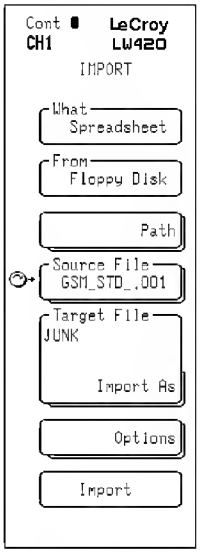


Figure 10.3 The Import Menu

Import As

Use this menu to enter a new name for the object to be imported.

Options

Pressing the **Options** softkey displays a menu used to selectoptions to process waveforms during import.

Import

Press the **IMPORT** softkey to import the object in **Source File** into the current project with the name in **Target File**. If it is not an LW4XX object then it will be converted to one because only LW4XX objects are stored in the WaveStation.

Export

To — This is the location to export the object to. Objects can only be exported to a floppy disk. Transfers between projects are handled by **Import.**

Project/Path — This is the actual path to store the objecti on the floppy disk. The path menu is shown below.

What — This field specifies what is to be exported, choices are Projects, Waveform, Sequence, Equations, or DSO files.

Format — This field only appears only if a waveform is being exported. This is the format in which to export the object in. The valid choices are: LW400 Waveform, MathCad, Matlab, spread sheet, or PSpice (PWL)

Source File — This is the object to be exported. The list contains the objects of the type in the current project.

Target File — This is the name to be used when the object is exported. It will duplicate the name in the **Source FIle** field unless it is changed with **Export As** (see below) at which point it will be the name entered.

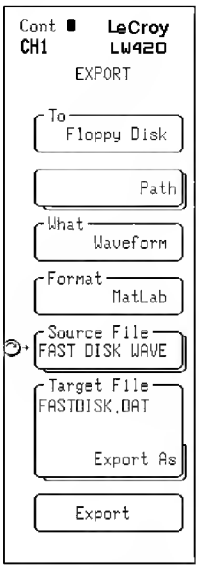


Figure 10.4 The Export Menu

Export As — This menu allows the user to enter a new name for the object to be exported.

Export — This is the action softkey that exports the object in Source File to the disk with the path as dictated by the Project/Path field in the format of the Format field with the name in Target File.

Preferences

The preferences menu, shown in the following figure, offers the choice of entering the System preferences menu or enabling Write Protect on the current project.

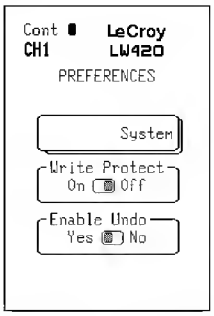


Figure 10.5 The Preferences Menu

System Menu

Pressing the **System** softkey will result in display of the SYSTEM menu shown in figure 10.6.

The functions of the SYSTEM menu softkeys are summarized in table 10.2 shown below.

Write Protect

This **On/Off** switch write protects the entire project. All waveforms and settings will be write protected. New waveforms, however, may be created, or imported. Waveforms may also be exported. *Note: that any waveform that is created in a write protected project is automatically write protected once it is saved.*

Enable Undo

Selecting **Yes/No** with the softkey enables/disables the undo buffer operation. This can speed up menu changes on very long waveforms

Softkey	Function
Logo (ON/OFF)	Turn The LeCroy LW400 logo on or off
Time/Date	Turn real time clock display on or off. Sets time and date.
Screen Saver (ON/OFF)	Enables screen saver
Noise Path (EXT/INT)	Selects internal or external path for asynchronous noise source. The external path is used to supply an external noise source and to filter or "color" the noise. On the LW400B, External is always selected.
GPIB	Used to set GPIB address of the LW400

Table 10.2

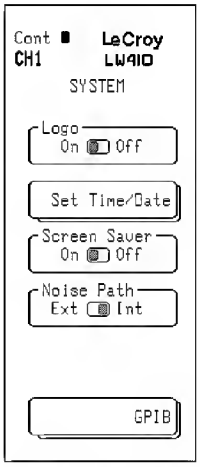


Figure 10.6 The System Menu

APPENDIX B

LW400/LW400A/LW400B WaveStation Specifications

Generator Mode

Standard Function Waveforms - 1 Hz Resolution
- Sine, 1 Hz - 100 MHz
- Square, 1 Hz - 50 MHz
- Triangle, 1 Hz - 25 MHz
- Ramp, 1 Hz - 25 MHz
- Pulse, (period)20 ns - max. memory
- DC

Frequency Sweep Linear / Log

Multitone, 1-10 tones, 1 Hz - 100 MHz

Arbitrary Functions:

Waveform Creation

Interactive Graphical editor on Internal 9" CRT

Standard Functions

Sine, Square, Triangle, Ramp, Pulse, DC

Equation Editor

Waveform (array) Math

Waveform Import From
- Digital Oscilloscope
- Floppy Disk

Waveform Feature Time Resolution:

100 ps

Available memory:

256k/ch. standard, 1 Mpoint optional

Minimum segment length:

64 points

Maximum segment length:

Up to available memory (1Mpoint when optional memory installed)

Segment length resolution:

1 point

Number of links:

512 for 256k memory

2048 for 1M memory

Internal Noise Generator:

Available in LW400 and LW400A only

Independent pseudorandom white noise generator with Gaussian distribution and 2^{22} states

Appendix B

Waveform Output Characteristics

Output channels:
LW410/LW410A - 1 Channel
LW420/LW420A - 2 Channel

Output Impedance:
50 Ω , ± 5%

DC Accuracy:
±(2% of setting +40 mV) for output > 500 mV peak-peak
±(2% of setting +15 mV) for output ≤ 500 mV peak-peak

Vertical resolution:
8 bits

Minimum output voltage:
10 mV p-p into 50 Ω

Maximum output voltage:
10 V p-p into 50 Ω

Offset voltage range:
± 5 V into 50 Ω. The output voltage (signal + offset) must be in the range ± 5 V into 50 Ω .

Offset voltage resolution:
0.05% of full scale

Output bandwidth:
100 MHz (-3dB) (widest bandwidth)

Total harmonic distortion:
<5 V p-p <-45 dBc (-50 dBc typical)
for sinusoidal output <=1MHz
<-35dBC
for sinusoidal output 1 MHz to 20 MHz (<-45 dBc typical)
<-25 dBc
to 50 MHz (<-40 dBc typical) (predominantly 2nd harmonic)

Spurious & non-harmonic distortion:
<-60 dBc for frequencies <=1 MHz for output

Signal-to-noise ratio:
>40 dB (-45 typical) for output amplitudes >100 mV @ 0 offset

Transition times: @ widest bandwidth with band limiting off
LW400/LW400A/LW400B: < 6 ns 10%- 90%
LW400/LW400A/LW400B: < 5 ns 10%- 90% @ widest bandwidth with band limiting off

Overshoot and ringing:
<8% of step size max. 3% typical

Settling time:
<50 ns to within 3% of step size @ widest bandwidth

Inter-channel crosstalk: <1%

Squarewave Symmetry: < 6 ppm + 0.5 ns

Pulse Generator Characteristics:

Pulse repetition frequency(max): 50 MHz
Pulse repetition frequency(min):
Limited by Channel memory and clock speed
Frequency accuracy: ± 3 ppm over operating temperature range
Pulse width(max): Limited by channel memory and clock speed
Pulse width(min): 10 ns
Pulse width accuracy:
± 3 ppm + 0.5 ns for widths > 2x the risetime
Pulse delay Characteristics:
Same as trigger delay with the following exception.
pulse time delay resolution = 1 ns

Ch 1 to Ch 2 skew:

<1 ns for identical waveforms in each channel (widest bw)

Output protection:

± 20 V

Output filtering:

The following filter cutoff frequencies will be available; 100 MHz Gaussian, 10 MHz Gaussian, 1 MHz Gaussian, 100 kHz Gaussian, 10 kHz Gaussian

Sample clock characteristics:

(with internal 10 MHz reference)

Maximum sample rate:

400 MS/second

Accuracy:

±3 ppm over operating temperature range

Stability:

Aging <1 ppm/year

SSB Phase Noise:

LW410/LW420: <-95 (-100 typical) dBc/Hz @ 10 KHz offset for a 10 MHz sine wave at output

LW410A/LW420A: <-90 dBc/Hz @ 10 KHz offset for a 10 MHz sine wave at output

Resolution: 1 Hz

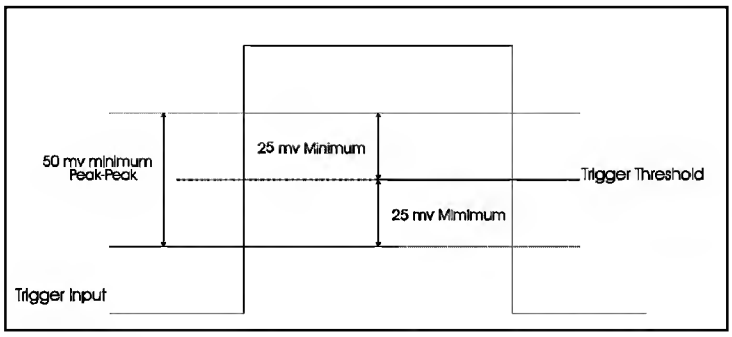
Variable Clock

LW400A and LW400B series only

Variable over range of 6 Khz to 400 MHz

Triggering Characteristics

Trigger slope:	Positive or Negative
Trigger input impedance:	50 Ω ± 5%
Threshold range:	± 2.5V
Threshold resolution:	20 mV
Threshold accuracy:	±100 mV
Threshold sensitivity:	50 mV minimum p-p
Minimum pulse width:	≤ 5 ns
Protection:	± 5 V



Trigger Modes

Continuous:

Runs continuously

Single:

Outputs 1 repetition of the waveform for each trigger received. Triggers received while the waveform is still running are ignored.

Burst:

Outputs the selected waveform a programmable number of times in response to a trigger. The maximum number of repetitions for a burst is 4,096. Triggers received while the burst is running are ignored.

Gated:

The waveform starts on the leading edge of the gate signal and stops on completion of the waveform cycle occuring at the trailing edge of the gate signal.

Trigger Delay

Minimum(min) delay time:

35 ns ±3.5 ns +5 sample clocks

Maximum delay time:

$(2^{32}-1)$ sample clocks

Delay resolution:

1 sample clock. The delay will be programmed in units of seconds. When operating from the front panel the resolution (sample clock period) will be shown to the user and the delay will change in increments of that value.

Delay accuracy:

± (0.0003% x programmed value)+min delay time+delay jitter

Note: The min delay time is a fixed value for each instrument at the selected sample clock rate. Considering this fact, the time delay at a specific sample clock rate can be measured and used to offset the programmed value to obtain the desired time delay.

offset programmed value = desired value - measured delay

In this case the delay accuracy is:
± (0.0003% x offset programmed value)+delay jitter

Delay jitter:

1 sample clock

Trigger Sources

Manual:

Front panel pushbutton

External:

Front panel BNC connector

GPIB:

A trigger command may be issued over the GPIB bus

Appendix B

Auxiliary Inputs

External 10 MHz reference: A rear panel input is provided that allows an external reference clock to be input. 400 mV p-p to 5 V p-p into 50 Ω.

Noise Input: ±500 mV maximum into 50 Ω.

Auxiliary Outputs

10 MHz reference output:

Frequency accuracy: ± 3 ppm
Amplitude (high): ≥ 1.6 v into 50 Ω
Amplitude (low): ≤ 0.2 v into 50 Ω

Timing marker:

1 bit of memory up to 128 transitions definable
Output levels:
ECL or TTL levels
Protection:
Outputs are protected to ± 5 V

Digital Output:

Channel 1 only, 8 bits and clock available from rear panel.
TTL/ECL logic levels simultaneously.

Noise In/Out: From rear panel BNC Connectors

Hard Copy Outputs

Supported Printers include:
Epson MX/FX
Epson LQ
HP LaserJet II
HP ThinkJet

Programmability

GPIB IEEE 488.2 compatible. Compliant with SCPI programming language. Capable of initiating and controlling waveform transfer from digital oscilloscopes by simply connecting a GPIB cable (no computer required).

General

Temperature:

5° C to 35° C full specifications;
0° C to 40° C operating;
-20° C to 70° C non-operating.

Humidity:

10% to 80% relative, non-condensing

Altitude:

< 2000 Meters (6560 ft)

Power:

90 - 132/180-250 V AC
47 - 63 Hz
4 amps @ 115 V AC (20 amps cold start surge)
2 amps @ 230 V AC (40 amps cold start surge)

The power supply is internally protected against short circuit and overload by means of a single T5.0A/250 V ~ fuse, which is not replaceable by the user.

Dimensions (HWD):

7.67, 14.92, 19.58 (inches)
19.5, 37.9, 49.7 (cm)

Weight:

27.6 lbs (12.5 kilograms)

Warranty: One year

Calibration Interval: Annually

CE Certifications: CE, UL and cUL

The Wavestation meets requirements of the EMC Directive 89/336/EEC for Electromagnetic Compatibility and Low Voltage Directive 73/23/EEC for Product Safety. See "Declaration of Conformity" certificate for details.

Warning: This is a Class A product. In a domestic environment this product may cause radio interference, in which case the user may be required to take adequate measures.

UL and cUL Certifcations:

UL Standard: UL 3111-1

Canadian Standard: CSA-C22.2 No. 1010.1-92

OUTPut#:NOISe:PATH

Purpose: Determines whether noise is routed through rear panel connectors for external filtering, or not.

Command: OUTPut#:NOISe:PATH <character data>

Query: OUTPut#:NOISe:PATH?

Response: EXTERNAL or INTERNAL

Arguments:: EXTernal or INTernal

Notes: OUTP1:NOISE:PATH and OUTP2:NOISE:PATH are coupled. There is one internal noise source, which feeds both channels.

The LW400B is always in EXTERNAL as it does not contain an internal noise source. Internal is not a valid argument on the LW400B. If the arugment INTERNAL is used the an error will be returned. The argument EXTERNAL remains a valid argument on all models.

OUTPut#:NOISe[:STATe]

Purpose: Enables or disables inserting uncorrelated pseudo-random noise into the waveform for the selected channel (1 or 2).

Command: OUTPut#:NOISe <Boolean>

Query: OUTPut#:NOISe?

Response: <Boolean>

Arguments: one of: 0, 1, OFF, ON

0 Disables noise.
1 Enables noise.
OFF Disables noise.
ON Enables noise.

WAVE:CLOCk:OPTime

Purpose: Set to YES and the WaveStation automatically selects the best sample clock rate and assures it is within one of the output filter ranges.

Set to NO enables use of the WAVE:CLOCK:LIMit and the WAVE:CLOCK:ACSet commands to be used for full clock control.

Command: WAVE:CLOCk:OPTime <character_data>

Query: WAVE:CLOCk:OPTime?

Response: <character_data>

Arguments: YES or NO

YES-automatic selection of sample clock rate.
NO-enables use of WAVE:CLOCK:LIMit and WAVE:CLOCK:ACSet commands.